Ongoing List of Topics:

- URL: [http://www.ece.mtu.edu/faculty/bamork/EE5223/index.htm](http://www.ece.mtu.edu/faculty/bamork/EE5223/index.htm)
- Labs - EE5224 - Lab 3 begins Wed Feb 13th
- Term Project - details coming after WC break.

Today:

- CT ratios, MR (multi-ratio) CTs - look at IEEE stds.
- Calculation of measurement error for given ratio & burden.

Next:

- Print out MOCT & CCVT handout from web page
- MOCTs - Magneto-Optic Current Transformers
  - Faraday effect, “faraday rotators,” Verdet constant
  - Shift of polarization angle due to strength of H-field
  - Design kept to low near-linear range
- Linear Couplers, Rogowski Coils
- CCVTs
- Voltage & Current relationships during faults, §3.5-3.10
\[ e = \frac{da}{dt} = \frac{N \Delta \phi}{\Delta t} \]

1. \( |\bar{I}_E| < 8 \Omega \Rightarrow \text{Error} < 10\% \)
2. \( |\bar{I}_E| > 8 \Omega \Rightarrow \text{Error} > 10\% \)
$G_1 \quad \text{Burden}$

$Z_B \Rightarrow L \Rightarrow A-t \Rightarrow \Phi \Rightarrow \text{Torque}$

$L = \frac{N_2^2}{A}$

$\Rightarrow \text{Low tap settings have highest } Z_B \text{ burden!}$

$Z_B \text{ is max}$

$Z_B \text{ is min}$

$G_2 \& G_3 \text{ relays: much smaller } Z_B$

But: look at I.h.!
\[
\left(\frac{1200}{5}\right) \times RCF = 1.004
\]

\[
240 \times 1.004 = 240.96
\]
ΦA-G Fault: Worst Case Burden

ECT sec cable + Relays

ΣB, TOT
$E \geq E$

4th iteration

0th

1.3

2nd

3rd

1.5

2.1 A

1st

$I_e$
\[ G_1 \text{ Burden} \]

\[ Z_B \Rightarrow L = L = \frac{N_1^2}{R} \]

\[ \Rightarrow \text{Low tap settings have highest } Z_B \text{ Burden!} \]

\( G_2 \& G_3 \text{ relays: much smaller } Z_B \)

But: look at I.L.!
FIGURE 5.12 Phase-and-ground relays for the protection of a circuit and the current distribution for a phase-and-ground fault.

16 Ω on its 0.5 A tap 68° lag. To pass pickup current through the ground relay, $0.5 \times 16 = 18$ V is required. This voltage, less the small drop through the phase relay circuit, will appear across the phase B and C current transformer secondaries to excite them. The voltage $V_{ef}$ depends on the current that, in turn, depends on the voltage, so the exact determination is a “cut-and-try” process. At the first try, assume that $V_{ef} = 8$ V. From the CT characteristic
L-G fault on Phase A.

- Refer to LØ3 notes on "Zones of Protection"
- Refer to CT notes posted on Week 4 (web page)
Phase A-G Fault

I_2 flows in CT even though its Pri. current is zero!
RCF: Keep \( \leq 1.1 \)

Typically, \( RCF > 1 \)

From previous example:

\[
\text{Ratio Actual} = \left( \frac{100}{5} \right) \times RCF = 20 \times \text{RCF} = 1.23
\]

\[
\text{RCF} = \frac{150}{6.1} = 24.6\text{A}
\]
\[
\left(\frac{1200}{5}\right) \times RCF = 1.004
\]

\[
240 \times 1.004 = 240.96
\]

1200 A

5 A

4.98

RCF

5 A

STD B-8 BURDEN!